

## CHAPTER VI

### CONCLUSIONS

The effects of addition of novolac epoxy resin into benzoxazine resin have been investigated. The liquefying temperature of the resin mixtures was observed to increase from 66 to 88.5°C with an increasing amount of the epoxy resin. Whereas, the gel temperatures of benzoxazine and novolac epoxy mixture were systematically shifted to higher temperature from 200.5°C to 222°C with the amount of novolac epoxy.

The heat treatment at 150°C for 1 hour, 170°C for 1 hour, 190°C for 1 hour, 200°C for 1 hour and 200°C for 2 hours was chosen as an optimum curing condition of polybenzoxazine (BA-a) and novolac epoxy copolymers due to the complete disappearance of an exotherm under their curing peak. From DMA experiment, it was found that the glass transition temperature ( $T_g$ ) showed a split into two values suggesting phase separation in the copolymers. However, in the polybenzoxazine and novolac epoxy binary mixture, the decreasing trend in  $T_g$  with an addition of epoxy resin was observed.

The coefficient of thermal expansion (CTE) of polybenzoxazine (BA-a) and novolac epoxy copolymers were decreased with the amount of the novolac epoxy from 46.80 ppm/°C to 20.97 ppm/°C due to the presence of the lower CTE of novolac epoxy fraction. Flexural strength and flexural strain-at-break of copolymer system were found to increase with increasing amount of the novolac epoxy, meanwhile, the flexural modulus of all copolymer was found to increase with increasing the amount of the novolac epoxy following the additivity rule.

The thermal expansion behavior of fiber glass-reinforced polybenzoxazine and novolac epoxy composite specimens were found to decreased from 24.26 to 20.97 ppm/°C. Very interesting that the fiber glass-reinforced of the pure polybenzoxazine was significant decrease of the CTE to 24.26 ppm/°C which pure polybenzoxazine given CTE at 46.8 ppm/°C. Flexural strength of reinforcement copolymers were found to increased from 114.6 to 241.8 MPa. However, flexural strain-at-break was slightly drop from 2.1 to 1.8% of pure polybenzoxazine matrix and water absorption the glass reinforcement imparts a high water absorption value due

to the high content of fiber glass-reinforced (80%). Hence, if decreasing the fiber glass reinforced and increasing polybezoazine and epoxy copolymer matrix will be improves the water absorption of the composite systems.